Rural and Remote Health rrh.org.au
James Cook University ISSN 1445-6354

REVIEW ARTICLE

Factors associated with teletrauma utilization in rural areas: a review of the literature

AUTHORS

Timothy Wood[1] MScN, BScN, RN *

Shannon Freeman[2] PhD, Associate Professor

Davina Banner[3] PhD, Associate Professor

Melinda Martin-Khan[4] PhD, Senior Research Fellow

Neil Hanlon[5] PhD, Professor

Frank Flood[6] Regional Manager

CORRESPONDENCE

*Mr Timothy Wood timothy.wood@alumni.unbc.ca

AFFILIATIONS

[1, 2, 3] School of Nursing, University of Northern British Columbia, Prince George, BC, Canada

[4] Centre for Health Services Research, Faculty of Medicine, University of Queensland, Brisbane, Qld, Australia

[5] School of Geography, University of Northern British Columbia, Prince George, BC, Canada

[6] Telehealth Department, Northern Health Authority, Prince George, BC, Canada

PUBLISHED

15 March 2021 Volume 21 Issue 1

HISTORY

RECEIVED: 11 August 2020

REVISED: 25 December 2020

ACCEPTED: 3 February 2021

CITATION

Wood T, Freeman S, Banner D, Martin-Khan M, Hanlon N, Flood F. Factors associated with teletrauma utilization in rural areas: a review of the literature. Rural and Remote Health 2021; 21: 6354. https://doi.org/10.22605/RRH6354

ETHICS APPROVAL

Ethical approval was not required as this was a knowledge synthesis of existing research.

ABSTRACT:

Introduction: Trauma patients residing in rural areas face increased challenges to accessing timely and appropriate health

services as a result of large geographic distances and limited resource availability. Virtual trauma supports, coined 'teletrauma', are one solution offered to address gaps in rural trauma care. Teletrauma represents a new and innovative solution to addressing health system gaps and optimizing patient care within rural settings. Here, the authors synthesize the empirical evidence on teletrauma research.

Methods: A review of literature, with no date limiters, was guided by Arksey and O'Malley's (2005) scoping review methodology. The aim of the review was to provide an overview of the current landscape of teletrauma research while identifying factors associated with utilization.

Results: Following a systematic search of key health databases, 1484 articles were initially identified, of which 28 met the inclusion criteria and were included for final analysis. From the review of the literature, the benefits of teletrauma for rural and remote areas were well-recognized. Several factors were found to be significantly associated with teletrauma utilization, including younger patient age, penetrating injury, and higher injury or illness severity. Lack of access to resources and clinician characteristics were also identified as reasons that sites adopted teletrauma services.

Conclusion: By identifying factors associated with teletrauma utilization, teletrauma programs may be used more judiciously and effectively in rural areas as a means of enhancing access to definitive trauma care in rural areas. Gaps in current knowledge were also identified, along with recommendations for future research.

Keywords:

Canada, emergency care telehealth, teletrauma, trauma.

FULL ARTICLE:

Introduction

Despite the existence of universal health care for Canadians, rural and remote communities have proportionately fewer health services and providers available[1] and experience disparities in health outcomes as a result. This problem is not unique to Canada; rural disparities are noted in many settings globally. Australia, for example, has long encountered recruitment and retention issues for rural areas[2,3]. Reasons attributed to these difficulties have included professional isolation[2] and a lack of local resources[3], leading to health inequities similar to those found in Canada. Many services have become centralized to more urban areas, requiring rural patients to travel longer distances for care. Compared to their urban counterparts, those residing in rural areas are the least likely to access specialist services[4]. A lack of availability of health services for rural patients can result in higher all-cause mortality rates[5], higher rates of avoidable deaths[6], and a three-fold increase in risk of death in the emergency department[7]. These gaps and differences in services are most important when considering trauma care for rural areas because trauma situations require a large amount of immediately available resources.

Teletrauma has been recognized as a possible solution for extending the geographical reach of regionalized trauma systems[8] and has been consistently adopted in rural areas[9-13]. For example, the implementation of teletrauma has been found to lead to a reduction in unnecessary transfers by identifying only those patients most in need of transfer, while stable patients are evaluated and eventually discharged locally[9]. Additionally, rural clinicians can perform otherwise unfamiliar procedures and develop professional skills, despite residing in areas with low user densities and less trauma exposure.

However, the current knowledge base on teletrauma for rural and remote areas is limited. To provide an overview of the empirical knowledge on teletrauma research and support knowledge synthesis, a systematic search of the literature was conducted. Knowledge gained from this literature review provides an understanding of the current state of teletrauma literature, and identifies gaps and potential directions for future teletrauma studies. Understanding why teletrauma is being utilized may permit insight into how programs may be used more effectively and judiciously in rural areas, promoting efficient use of limited resources.

Methods

This literature review was guided by Arksey and O'Malley's[14] scoping review methodology. This method was selected to identify, describe, and summarize the knowledge base of relevant literature on teletrauma.

Five electronic databases were searched: Cumulative Index to Nursing and Allied Health Literature (CINAHL) Complete, Biomedical Reference Collection: Comprehensive, PsycINFO, EconLit, and PubMed. Keywords included terminology related to any telehealth service, trauma, and a rural setting, while relevant subject headings were used according to the database searched (Supplementary table 1). The search was peer reviewed by a health sciences librarian. No date or age limiters were used, because limited research was available. The search was restricted to peer reviewed articles available in English, and human subjects. Inclusion criteria consisted of care provided in a clinic, hospital, or emergency department and articles having a telehealth component to retain a focus on telehealth services provided within rural institutions. Articles were excluded if there was no acute or emergency care situation, or if there was no real-life clinical component. A matrix was created with clearly defined rules for the screening process to ensure reliability of the review. The number of excluded articles was recorded at each step. After an initial screening of titles and abstracts, full-text articles were reviewed according to the eligibility criteria (Fig1).

A data extraction framework was used to organize and ensure consistency of data collection (Supplementary table 2). Framework headings were created according to the research questions and to

provide a descriptive overview of the current literature.

The Quadruple Aim framework[15] was used to help categorize articles according to evaluation aim. Aims include provider experience, patient experience, population health, and cost optimization. Use of the Quadruple Aim framework for this literature review permits identification of aspects of the healthcare system being examined and highlights gaps in teletrauma evaluation research.

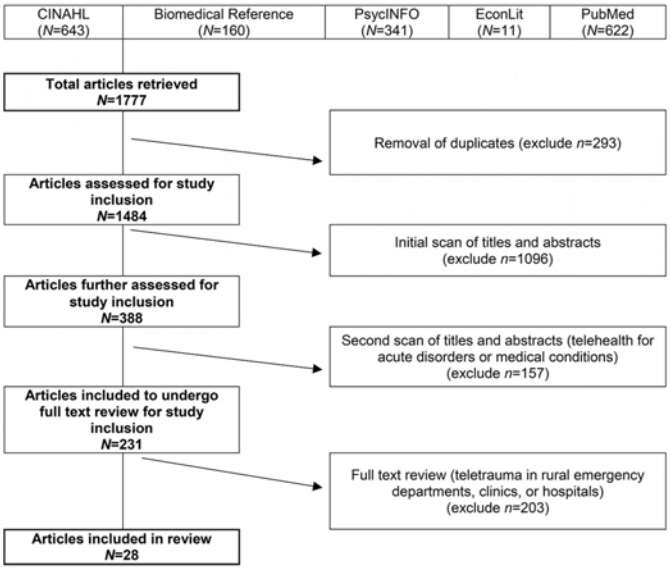

Figure 1: Article selection flowchart.

Supplementary table 1: Search strategy by database using keywords and subject headings

Supplementary table 2: Summary of teletrauma studies included in the review (*n*=28, article date range 1997–2018)

Results

From the original 1777 articles identified in the initial search, 28 articles met the eligibility criteria and were included in the analysis (Supplementary table 2). Of the studies identified, 16 focused on patient populations that were classified as trauma cases. The remaining 12 articles examined cases meeting the definition of traumatic injury (acute injuries requiring immediate medical management) and were thus included, but did not specifically classify patients as being trauma patients. Subheadings were selected to best address the various aspects of the research question and to highlight commonalities or inconsistencies uncovered in the review. Examples are what constitutes a teletrauma service in terms of technology, or what is meant by 'rurality', 'acceptability', and 'feasibility', as this terminology is commonly used but often not explicated. A comprehensive service evaluation framework provided a guide for understanding the effects of teletrauma across all dimensions of the healthcare system.

Study characteristics

A large proportion of articles were published within the past 10 years (*n*=12) although teletrauma research has appeared as early as 1997[10,16,17]. Three studies utilized observational cohort study designs[11,18,19], six were classified as descriptive analyses[12,16,20-23], three were identified as comparative or before-and-after studies[13,24,25], while the most frequently used design was a retrospective analysis (*n*=11). Studies were conducted in 11 different countries, the most common being the USA (*n*=15) and Canada (*n*=3).

Of the 28 studies, 61% (*n*=17) included a non-teletrauma comparison group in analysis (ie trauma with no telehealth component, or phone consultation only). The largest teletrauma sample sizes examined was 1322 telehealth consultations regarding an injury[26]. The study with the smallest teletrauma sample size was a case report of a traumatically injured child (*n*=1) who received remote clinical management prior to transfer[17]. Articles with a study population that included patients of all ages constituted 61% (*n*=17) of the total, followed by pediatric patients under the age of 18 years (*n*=7) and adults over 18 years (*n*=4).

The communication network for teletrauma programs varied in size: one article studied telehealth consultations for acute injuries from 14 community hospitals consulting a larger hospital[26]; another examined a telehealth service between nine rural hospitals consulting a Level 1 trauma center to evaluate and manage burns patients[27]. The largest network included maxillofacial trauma cases from 35 rural hospitals consulting a specialized center[12]. Typically, articles described teletrauma services between a single rural community hospital or emergency department and a center with a higher level of care (*n*=13).

Terminology in the literature

The term 'teletrauma' is associated with the use of telehealth technologies for trauma care and management. Few articles[28,29]

used the term 'teletrauma' to describe a telehealth system designed for use during trauma care. Instead, several studies labelled their telehealth service based on the specific technology used. These included tele-ultrasound[20], teleradiology[21], and telesonography[22]. Although the functions of the individual systems are similar, the services were labelled based on their diagnostic or technological focus. Despite the lack of a formal definition, all telehealth technologies used at any point during the management of traumatic injury may be generalized as 'teletrauma', regardless of a focus on a particular aspect of care (eg sonography, basic consultation, or airway management). In summary, there was a lack of consistency in terminology related to teletrauma, and this may preclude knowledge synthesis in this field. The use of the prefix 'tele-' and attaching the clinical function of the service challenges the identification and evaluation of teletrauma literature more broadly.

The definition of 'rural' varied between articles. Some articles stated that the client site was rural or remote but did not elaborate on how this was defined[20,23,27,30,31]. Others used officially recognized rural zones, whether provided by a government body or healthcare organization, to classify sites as rural[11,18,32,33]. However, several articles expanded on the meaning of 'rural' by describing the remote facility characteristics and surrounding geography in relation to a larger center. Thus, rurality was described in distinct ways across the literature.

Several aspects of rurality were identified, including geographic separation[9,26], lack of appropriate resources[21,22], temporal barriers to care[12,13,25], or some combination of these. It may be of use for future studies to define rurality in terms of these characteristics in addition to the accessibility of surrounding higher level services. This will aid in understanding the local context of health service delivery and how telehealth operates within that context, facilitating more accurate service evaluation.

Essential system components

Despite the varied language used, the essential components required for telehealth emergency services in rural areas were consistent throughout the literature. For trauma care, this typically included a real-time, bidirectional audio-visual videoconferencing system with a dedicated network line[9,22,28,29]. It was common for teletrauma systems to have mounted cameras with remote control capabilities[9,29,33-35]; however, most articles described the system only as having cameras with pan/tilt/zoom functions. Although different technologies and techniques have been used to establish a teletrauma system, more than half of the articles (n=15) used some form of video-conferencing. This has included a two-way audio-visual connection[11,18,19,36], audio-visual communication system[25,29,33-35], transmission of audio, visual, and vital signs[28], and the explicit mention of a video-conference system[9,16,20,22,23,26,32,37]. For teletrauma systems deployed in rural areas, there were similarities in the types of technology used and the technological capabilities.

The design, specific elements, and capabilities of the telehealth system were driven by the needs of the clinical situation in which it was employed, provided appropriate local infrastructure was in place to facilitate the technological requirements. The technological components supported assessment of the patient by several parties at a distance in real time without requiring staff at the client site to position cameras[9,29]; a virtual presence is established at the client site with minimal interference to onsite staff. The similarities in technological components for rural teletrauma identified across the literature support the future development of teletrauma systems designed to meet the needs of patients and providers. Further knowledge syntheses in this area may be used to contribute to the creation of technological guidelines for rural sites wishing to adopt teletrauma services. The differences in technological components identified in the literature highlight the variability of technology capable of enabling a teletrauma service, while the commonalities in technology can help to elucidate the specific requirements for teletrauma deployment given the clinical demands.

Service evaluation aim

Examination of service evaluation aim permits insight into how the healthcare system is being affected by teletrauma services and identifies gaps in research. The majority of the included articles were classified as having only examined one aspect of Bodenheimer and Sinsky's Quadruple Aim[15]. The most frequently evaluated aim was population health (n=26). Population health evaluation, in the context of teletrauma, included analysis of the safe medical management of patients[21], transfer rates[9], and clinical outcomes for patients[37]. Provider and patient experience was typically evaluated using quality of care measures[28,32] or satisfaction surveys[16,20,22,26]. Evaluation aims studied the least were patient experience[13,32,36] and cost optimization[9,13,28,35]. Articles categorized under the cost optimization aim included those evaluating transfer costs for teletrauma patients[13,28], assessment of total hospital charges[9], and a formal economic analysis[35]. Teletrauma service evaluations covering three or more aims were less common[13,28,32,36] and usually included an examination of patient and provider experience as well as population health. Articles with combined evaluation aims typically included written surveys distributed to patients or providers and either a cost assessment or examination of clinical outcomes; one identified changes in diagnosis or therapeutic management of patients[32], whereas another evaluated patient transport costs[13,28].

While articles covering several evaluation aims could be considered more comprehensive, each individual aim appeared to be less robustly studied compared to those articles focusing on only one aim. For example, Saffle et al distributed a Likert scale containing only four questions to patients and providers to assess their experience using teletrauma[13]. Ricci et al, on the other hand, used a more robust method to assess patient and provider experience which included interviews, in-person observations, and questionnaires[29]. This provided a more in-depth analysis of the teletrauma-user experience through examination of attitudes, perceptions, and behaviors of patients and providers. A similar finding was discovered for the cost optimization aim; many studies postulate that teletrauma was (or could be) cost-saving, whereas Yang et al provided more formal analysis of associated costs[35].

Although it is useful for research to include all aspects of the Quadruple Aim[15] to fully understand the effects of a service across the entire health system, it may be advantageous to capitalize on the robustness of single- or double-aim studies by synthesizing knowledge from several articles. Knowledge synthesis in this area contributes to a more comprehensive understanding of how teletrauma affects health systems while relying on robust studies that focus on only one or two aims.

Using Bodenheimer and Sinsky's Quadruple Aim framework[15], it was identified that service evaluation aims across articles were unbalanced. Population health was studied most frequently, while patient experience and cost optimization were evaluated the least, highlighting areas across the health system where service evaluation may be lacking.

Acceptability

The user experience is frequently evaluated in studies examining teletrauma services[13,16,20,22,25,29,32,34,38]. Teletrauma users include a variety of individuals involved with the encounter, including healthcare professionals (nurses, doctors, specialists) from both the client site and consulting site, patients, and family members of the patient. Likewise, one article, examining the impact of teletrauma for critically injured children, evaluated parent as well as provider satisfaction using validated surveys[32]. The authors measured various aspects of acceptability, assessing quality of care, changes in care, and satisfaction for teletrauma or telephone consultations. Results were then combined with quantitative analysis of the teletrauma and telephone consultations, providing a methodologically rigorous examination of user experiences in the context of pediatric trauma care.

Studies involving patient (or family) and provider perceptions of teletrauma have produced positive results, although 'acceptability' is measured in different ways across articles identified; clinicians have judged the system to be easy to use[29], collegiality between the client and consulting sites was improved[20,22,25], and up to 92% of providers were satisfied or very satisfied with a teletrauma interaction[20]. Teletrauma services for rural environments are also reportedly life-saving[17,29,34]. In two cases, a rural clinician was guided through an unfamiliar emergency procedure by an expert consultant, saving the life of the patient: Rogers et al described a successful emergency cricothyroidotomy by a community hospital surgeon who had not performed the procedure in more than 20 years[34]; Rottger et al mentioned that a craniotomy, a procedure that normally would have been conducted by a neurosurgeon, was successfully performed by a rural physician not trained on the procedure[17]. In both cases, teletrauma adequately facilitated safe and appropriate management.

Thus, 'acceptability' of teletrauma services can be considered an umbrella term that includes satisfaction, usability, and perceived value. Of these concepts, satisfaction was frequently used to capture patient or provider perspectives of teletrauma systems (n=7), reflecting acceptability of the service. However, while satisfaction with teletrauma services was generally positive, the full scope of benefits can be difficult to measure[28] and thus the concept of acceptability should not be limited only to satisfaction as a proxy measure.

Feasibility

Across the literature, teletrauma was noted as being feasible; five articles explicitly mention the service as being feasible[22,23,27,29,36]. However, the concept of feasibility was measured in distinct ways across the various studies. Some examples of teletrauma feasibility include effective and reliable clinical ultrasound exam performance[22], reliable use of satellite communication to support remote doctors[23], accurate burn size estimation[27], decreased overall hospital costs[9], and lesser costs for video-conferencing compared to telephone when considering transfer decisions[33]. Therefore, 'feasibility' can be further categorized into clinical feasibility (accurate diagnosis), economic feasibility (cost-saving), and technical feasibility (reliable technology). Clinical feasibility was most commonly described in terms of therapeutic management or quality of care received (n=17). For example, Dharmar et al[32] reported more changes in diagnosis and therapeutic interventions for patients who had teletrauma as compared to those with telephone consultations, resulting in a higher quality of care for teletrauma patients (5.60 (95% confidence interval (CI) 5.42–5.79) v 5.20 (95%CI 5.07–5.34), p<0.05, as measured on a seven-point scale). Teletrauma also facilitates the rapid identification and transfer of more severely injured rural patients, improving care[9]. In both cases, the teletrauma systems were judged as being feasible. Across identified articles, the term 'feasible' was used to represent a variety of conceptual categories. It may be useful for future research to adopt a common definition of feasibility in the context of teletrauma to facilitate program evaluation and allow for more robust comparisons.

Factors associated with teletrauma use

Associated factors can be categorized as being either antecedent (identifiable prior to the telehealth event) or as outcomes (identifiable after the telehealth event). These can be further subdivided into clinical or organizational factors. This classification system supports a targeted approach to teletrauma utilization where the system is activated only for those patients who may benefit most, identified and selected based on certain clinical and organizational criteria. Whereas some articles examined factors antecedent to individual teletrauma encounters and may therefore be used to screen patients, other studies cited reasons for adopting the teletrauma service as a whole.

Antecedent factors: Antecedent clinical factors included injury or trauma severity scales[9,19,29,33,34,36], limb injury location[16,26,30], mechanism of injury[9,19,28], and patient age[10,32,33,35,36].

Several clinical factors were found to be significantly associated with use of a teletrauma service. Scales were frequently used to evaluate the severity of injuries in trauma patients, including the Injury Severity Score[39] or Revised Trauma Score[40]. It has been found that severely injured patients were more likely to receive a teletrauma consultation. Duchesne et al, for example, compared a cohort of patients who did not have teletrauma (n=351) to a group of patients that received teletrauma (n=51) to evaluate outcomes

for rural patients[9]. The authors found that teletrauma patients had an Injury Severity Score of 18, compared to 10 for those patients who did not receive teletrauma ($p<0.001$). The authors also mentioned that they were able to select more severely injured patients, resulting in more aggressive treatment early on in the care management process. Similarly, Mohr et al[19] found that, as compared to patients with minor injuries, those with severe injuries were 70% more likely to receive a teletrauma consultation (unadjusted odds ratio (OR) 1.70, 95%CI 1.13–2.56). This finding is echoed by several other studies reporting on injury severity or physiological illness[9,29,33,34,36]. Specific symptoms and mechanisms of injury have also been examined. Mohr et al found that patients presenting with hypotension, penetrating injury, tachycardia, and burns were more likely to receive teletrauma[19], while Duchesne et al identified hypotension, penetrating injury, higher initial base deficit, and the need for more blood transfusions as being associated with teletrauma use[9]. Younger patient age was also found to be significantly associated with teletrauma use in a number of studies[10,32,33,35,36]. Marcin et al reported a mean age of 5.5 years for teletrauma patients versus 13.3 years for non-teletrauma patients ($p<0.01$) [36]. Similar results in an adult population were demonstrated by Mohr et al who found that, as compared to younger patients, adults aged 65 years and older were 4.7 times less likely to receive teletrauma (risk difference –4.7, 95%CI –8.6 to –0.8)[11].

Antecedent organizational and hospital-level factors were also examined in 14 of the captured literature[9,12,13,17,18,20-25,27,32,37]. Antecedent organizational factors included access to specialist knowledge or services[9,12,13,21-23,25,37], number of unnecessary transfers[21,24], clinical experience of local health professionals[17,20,27,32], and hospital-level factors included rurality, number of trauma cases, and distance to a facility with a higher level of care[18].

Mohr et al[18] found that geographic factors such as rurality and distance to a facility with a higher level of care did not significantly explain variability in teletrauma use. However, the authors mentioned that the rural facilities all had similar capabilities resulting in a lack of variation of usage after teletrauma was adopted. Access to specialist knowledge or services was a commonly cited reason to adopt and use teletrauma ($n=7$). Saffle et al[13] identified that untimely subspecialist involvement was a challenge overcome through the deployment of a teletrauma system. Physician confidence with therapeutic management and clinical experience were also factors identified in the literature; a lack of physician experience or familiarity with certain clinical situations have been noted as justification to adopt a teletrauma system[20,27]. Similarly, physicians were more likely to initiate a teletrauma consultation if they were uncertain of the diagnosis or clinical management of a patient[32].

Outcome factors: Clinical outcome factors associated with teletrauma use were frequently reported by studies ($n=14$), including mortality[9], length of stay[11,25], and perceived quality of care received[23,28,32,36]. Duchesne et al[9] noted that despite teletrauma being used for more severely injured patients, mortality did not differ significantly (17 (4.8%) pre-teletrauma v 4 (7.8%) post-teletrauma, $p>0.05$). The availability of teletrauma was also associated with an increase in length of stay for transferred patients (12.6 minutes, 95%CI 0.6–24.6) and non-transferred patients (15.6 minutes, 95%CI 9.7–21.4).

Organizational outcome factors were also studied, and included transfer rate or status[11,12,16,19,23-26,28,33,35] and cost[9,13,28,35]. Roccia et al, for example, noted a 50% reduction in the number of transfers to a specialist center as a result of teletrauma use[12]. Cost reduction was also often associated with reduced transfers; Latifi et al noted that 29% ($n=17$) of transfers were prevented, saving an estimated $104,852 in transfer costs[28]. Lower costs as a result of implementing teletrauma were consistently mentioned in the literature[9,13,28,35].

Discussion

The 28 articles included in this review provide insight into how teletrauma functions within rural settings and the effects of teletrauma on population health, patients, providers, and the health care system. Positive outcomes of teletrauma supports were well recognized; numerous articles explicitly mentioned the utility of teletrauma for rural areas[9,17,20,22,29,34,37]. As well, several antecedent factors associated with teletrauma utilization were delineated. These factors were categorized as being either clinical (eg demographics, signs and symptoms, medical interventions) or organizational (eg staff clinical experience, hospital rurality). Classifying these factors aided in understanding how various aspects of the care system may be used to target patients for teletrauma consultation. Although several elements, such as lack of access to timely specialist involvement and lack of physician familiarity with or confidence during major trauma, can be used to identify and select sites that may benefit from teletrauma, other elements can be used to develop a selective strategy for individual teletrauma encounters. Mohr et al explicitly call for a targeted approach to teletrauma utilization[11]. Uncovering the factors significantly associated with teletrauma use may lead to more judicious use of teletrauma resources in rural areas by identifying and selecting those patients who may benefit most. In this regard, it may be of use to employ a combination of clinical and organizational factors to select sites and patients for targeted teletrauma utilization. Whereas rurality, distance to a higher level of care facility, or lack of trauma resources are strong indications for teletrauma service adoption, clinical factors are less clearly indicative of when a teletrauma service should be used and warrant further investigation.

Studies also reported on a variety of factors associated with use of a teletrauma system. Few articles examined signs and symptoms of patients, in addition to other clinical and demographic information[9,19]. Although specific physiological signs (base deficit, tachycardia) may be used to select patients for future teletrauma use, further study is needed before this information can be clinically useful. On the other hand, several articles reported on other patient-level factors, identifiable prior to a teletrauma encounter, that are generalizable to and useful for future trauma cases. It was consistently found that younger patient age[10,11,19,32,33,35,36], penetrating injury[9,19], and high severity of

illness or injury[9,29,34,36] were significantly associated with teletrauma use. These findings can be used to support the development of criteria to select patients for targeted teletrauma use, such as a screening tool that may flag patients based on physiological or demographic information. However, it is important to recognize the complexity of trauma care in rural areas and the role of the provider. Given the large variety of resources available in rural areas and the variability of provider experience and comfort with trauma care, the decision to use teletrauma must not be based on clinical factors alone. It is essential that the provider be taken into account when deciding how to target teletrauma services in rural geographies.

None of the included studies specifically explored the experiences of physicians using teletrauma, and other stakeholders engaged in the planning and delivery of healthcare services. Further research to delineate these perspectives is needed to inform a comprehensive understanding of teletrauma services within a rural setting. Most notably, it may be necessary to examine how different teletrauma technologies support or hinder rural trauma care and how interprofessional relationships influence teletrauma encounters. As such, a next step may be to examine the use of teletrauma from the perspective of services users. Combining this data with the aforementioned clinical and organizational factors may constitute a strong step forward towards sustainable, effective, and efficient teletrauma system deployment in rural areas.

Conclusion

Rural trauma patients face increased challenges to accessing timely and appropriate health care. Teletrauma may be one solution, facilitating access to health services and resources. This review identifies gaps in current teletrauma research and highlights areas for further clinical and health services research. By identifying factors associated with teletrauma utilization, teletrauma programs may be used more judiciously and effectively in rural areas while enhancing access to definitive trauma care in rural areas. Gaps in current knowledge were also identified, including rigorous evaluation of why physicians use teletrauma. To address this identified need, further research is needed with an emphasis on the experiences of teletrauma users.

REFERENCES:

1 Pong RW, DesMeules M, Heng D, Lagace C, Guernsey JR, Kazanjian A, et al. Patterns of health service utilization in Canada. *Chronic Diseases and Injuries in Canada* 2011; **31(Suppl1):** 1-36. DOI link, PMid:22047772

2 Lannin N, Longland S. Critical shortage of occupational therapists in rural Australia: changing our long-held beliefs provides a solution. *Australian Occupational Therapy Journal* 2003; **50:** 184-187. DOI link

3 Curran VR, Fleet L, Kirby F. Factors influencing rural health care professionals' access to continuing professional education. *Australian Journal of Rural Health* 2006; **14:** 51-55. DOI link, PMid:16512789

4 Sibley LM, Weiner JP. An evaluation of access to health care services along the rural-urban continuum in Canada. *BMC Health Services Research* 2011; **11:** 20. DOI link, PMid:21281470

5 Kulig JC, Williams AM (Eds). *Health in rural Canada.* Vancouver, BC: UBC Press, 2012.

6 Canadian Institute for Health Information. *Your health system: avoidable deaths.* 2017. Available: web link (Accessed 18 August 2020).

7 Gomez D, Berube M, Xiong W, Ahmed N, Haas B, Schuurman N, et al. Identifying targets for potential interventions to reduce rural trauma deaths: a population-based analysis. *Journal of Trauma and Acute Care Surgery* 2010; **69(3):** 633-639. DOI link, PMid:20016384

8 Hameed SM, Schuurman N, Razek T, Boone D, Van Heest R, Taulu T, et al. Access to trauma systems in Canada. *Journal of Trauma and Acute Care Surgery* 2010; **69(6):** 1350-1361. DOI link, PMid:20838258

9 Duchesne JC, Kyle A, Simmons J, Islam S, Schmieg Jr RE, Olivier J, et al. Impact of telemedicine upon rural trauma care. *Journal of Trauma and Acute Care Surgery* 2008; **64(1):** 92-98. DOI link, PMid:18188104

10 Franken Jr EA, Harkens KL, Berbaum KS. Teleradiology consultation for a rural hospital: patterns of use. *Academic Radiology* 1997; **4(7):** 492-496. DOI link

11 Mohr NM, Vakkalanka JP, Harland KK, Bell A, Skow B, Shane DM, et al. Telemedicine use decreases rural emergency department length of stay for transferred North Dakota trauma patients. *Telemedicine and e-Health* 2018; **24(3):** 194-202. DOI link, PMid:28731843

12 Roccia F, Spada MC, Milani B, Berrone S. Telemedicine in maxillofacial trauma: a 2-year clinical experience. *Journal of Oral and Maxillofacial Surgery* 2005; **63(8):** 1101-1105. DOI link, PMid:16094576

13 Saffle JR, Edelman L, Theurer L, Morris SE, Cochran A. Telemedicine evaluation of acute burns is accurate and cost-effective. *Journal of Trauma and Acute Care Surgery* 2009; **67(2):** 358-365. DOI link, PMid:19667890

14 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology* 2005; **8(1):** 19-32. DOI link

15 Bodenheimer T, Sinsky C. From triple to quadruple aim: care of the patient requires care of the provider. *The Annals of Family Medicine* 2014; **12(6):** 573-576. DOI link, PMid:25384822

16 Lambrecht CJ. Telemedicine in trauma care: description of 100 trauma teleconsults. *Telemedicine Journal* 1997; **3(4):** 265-268. DOI link, PMid:10176007

17 Rottger J, Irving AM, Broere J, Tranmer B. Use of telecommunications in a rural emergency. Brain surgery by fax. *Journal of Telemedicine and Telecare* 1997; **3(1):** 59-60. DOI link,

PMid:9139763

18 Mohr NM, Harland KK, Chrischilles EA, Donner J, Bell A, Shane DM, et al. Telemedicine penetration and consultation among rural trauma patients in critical access hospital emergency departments in North Dakota. *RTRC Research & Policy Brief* 2016; 1-4.

19 Mohr NM, Harland KK, Chrischilles EA, Bell A, Shane DM, Ward MM. Emergency department telemedicine is used for more severely injured rural trauma patients, but does not decrease transfer: a cohort study. *Academic Emergency Medicine* 2017; **24(2):** 177-185. DOI link, PMid:28187248

20 Al-Kadi A, Dyer D, Ball CG, McBeth PB, Hall R, Lan S, et al. User's perceptions of remote trauma telesonography. *Journal of Telemedicine and Telecare* 2009; **15(5):** 251-254. DOI link, PMid:19590031

21 Ashkenazi I, Haspel J, Alfici R, Kessel B, Khashan T, Oren M. Effect of teleradiology upon pattern of transfer of head injured patients from a rural general hospital to a neurosurgical referral centre. *Emergency Medicine Journal* 2007; **24(8):** 550-552. DOI link, PMid:17652675

22 Dyer D, Cusden J, Turner C, Boyd J, Hall R, Lautner D, et al. The clinical and technical evaluation of a remote telementored telesonography system during the acute resuscitation and transfer of the injured patient. *Journal of Trauma and Acute Care Surgery* 2008; **65(6):** 1209-1216. DOI link, PMid:19077603

23 Ehrlich AI, Kobrinsky BA, Petlakh VI, Rozinov VM, Shabanov VE. Telemedicine for a children's field hospital in Chechnya. *Journal of Telemedicine and Telecare* 2007; **13(1):** 4-6. DOI link, PMid:17288651

24 Jacobs JJ, Jacobs JP, van Sonderen E, van der Molen T, Sanderman R. Fracture diagnostics, unnecessary travel and treatment: a comparative study before and after the introduction of teleradiology in a remote general practice. *BMC Family Practice* 2015; **16(1):** 53. DOI link, PMid:25943473

25 Westbrook JI, Coiera EW, Brear M, Stapleton S, Rob MI, Murphy M, et al. Impact of an ultrabroadband emergency department telemedicine system on the care of acutely ill patients and clinicians' work. *Medical Journal of Australia* 2008; **188(12):** 704-708. DOI link, PMid:18558892

26 Brebner EM, Brebner JA, Ruddick-Bracken H, Wootton R, Ferguson J, Palombo A, et al. Evaluation of an accident and emergency teleconsultation service for north-east Scotland. *Journal of Telemedicine and Telecare* 2004; **10(1):** 16-20. DOI link, PMid:15006210

27 Wibbenmeyer L, Kluesner K, Wu H, Eid A, Heard J, Mann B, et al. Video-enhanced telemedicine improves the care of acutely injured burn patients in a rural state. *Journal of Burn Care and Research* 2016; **37(6):** e531-e538. DOI link, PMid:26132049

28 Latifi R, Weinstein RS, Porter JM, Ziemba M, Judkins D, Ridings D, et al. Telemedicine and telepresence for trauma and emergency care management. *Scandinavian Journal of Surgery* 2007; **96(4):** 281-289. DOI link, PMid:18265854

29 Ricci MA, Caputo M, Amour J, Rogers FB, Sartorelli K, Callas PW, et al. Telemedicine reduces discrepancies in rural trauma care. *Telemedicine Journal and e-Health* 2003; **9(1):** 3-11. DOI link, PMid:12699603

30 Elkaim M, Rogier A, Langlois J, Thevenin-Lemoine C, Abelin-Genevois K, Vialle R. Teleconsultation using multimedia messaging service for management plan in pediatric orthopaedics: a pilot study. *Journal of Pediatric Orthopaedics* 2010; **30(3):** 296-300. DOI link, PMid:20357598

31 Lienert N, Zitzmann NU, Filippi A, Weiger R, Krastl G. Teledental consultations related to trauma in a Swiss telemedical center: a retrospective survey. *Dental Traumatology* 2010; **26(3):** 223-227. DOI link, PMid:20406276

32 Dharmar M, Romano PS, Kuppermann N, Nesbitt TS, Cole SL, Andrada ER, et al. Impact of critical care telemedicine consultations on children in rural emergency departments. *Critical Care Medicine* 2013; **41(10):** 2388-2395. DOI link, PMid:23921273

33 Yang NH, Dharmar M, Kuppermann N, Romano PS, Nesbitt TS, Hojman NM, et al. Appropriateness of disposition following telemedicine consultations in rural emergency departments. *Pediatric Critical Care Medicine* 2015a; **16(3):** e59-e64. DOI link, PMid:25607743

34 Rogers FB, Ricci M, Caputo M, Shackford S, Sartorelli K, Callas P, et al. The use of telemedicine for real-time video consultation between trauma center and community hospital in a rural setting improves early trauma care: preliminary results. *Journal of Trauma and Acute Care Surgery* 2001; **51(6):** 1037-1041. DOI link, PMid:11740247

35 Yang NH, Dharmar M, Yoo BK, Leigh JP, Kuppermann N, Romano PS, et al. Economic evaluation of pediatric telemedicine consultations to rural emergency departments. *Medical Decision Making* 2015; **35(6):** 773-783. DOI link, PMid:25952744

36 Marcin JP, Schepps DE, Page KA, Struve SN, Nagrampa E, Dimand RJ. The use of telemedicine to provide pediatric critical care consultations to pediatric trauma patients admitted to a remote trauma intensive care unit: a preliminary report. *Pediatric Critical Care Medicine* 2004; **5(3):** 251-256. DOI link, PMid:15115563

37 Syed-Abdul S, Scholl J, Chen CC, Santos MD, Jian WS, Liou DM, et al. Telemedicine utilization to support the management of the burns treatment involving patient pathways in both developed and developing countries: a case study. *Journal of Burn Care and Research* 2012; **33(4):** e207-e212. DOI link, PMid:22249104

38 Mueller KJ, Potter AJ, MacKinney AC, Ward MM. Lessons from tele-emergency: improving care quality and health outcomes by expanding support for rural care systems. *Health Affairs* 2014; **33(2):** 228-234. DOI link, PMid:24493765

39 Baker SP, O'Neill B, Haddon Jr W, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma and Acute Care Surgery* 1974; **14(3):** 187-196. DOI link

40 Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the Trauma Score. *The Journal of Trauma* 1989; **29(5):** 623-629. DOI link, PMid:2657085

Supplementary material is available on the live site https://www.rrh.org.au/journal/article/6354/#supplementary